# Sfb 1946 — A1

# Coupled Simulation of Heterogeneous Hydrological Systems: Numerical Modeling of Runoff Generation in Lowland Areas

R. Kornhuber (FU Berlin), E. Bänsch (FU/WIAS Berlin),
A. Bronstert (U Potsdam)

## Motivation

Lowland areas with high water tables are typical landscapes in NE-Germany.
They are **both** important for agriculture **and** ecologically high valued.
The quantification of water resources and the dominating hydrological processes in lowlands is required:

- for a sustainable agricultural use of these landscapes,
- for the preservation of their ecological value and
- for the environmental impact-analysis of management measures.

High water levels
in the Lower Havel region

Protected birds habitat
in the Lower Havel region

Hydrological systems of such environments are very complex:

- Various interactions of hydrological processes and compartments, e.g. unsaturated soil zone, ground water, and surface water
- Very strong space–time variations of the governing processes
- Understanding of these coupled systems by the use of mathematical models of the governing hydrological processes and their interactions

## Goal

**The overall goal of this project is to improve the understanding of the complex hydrological lowland system by means of refined numerical modeling methods.**

## Hydrological Modeling

Most state–of–the–art hydrological models reflect the fluxes between surface and sub–surface compartments in an *uncoupled mode*, i.e. without feedback mechanisms.
Therefore, they are hardly suitable for the simulation of runoff generation in *lowland areas*, where the interaction of unsaturated soil, ground water and surface water might dominate other hydrological processes.

## Research Strategy

### Identification and monitoring of a selected lowland catchment

- measurements of spatial data
- time series of processes

Satellite image of our research catchment:


- surface–water observation station
- ground–water observation station
- soil–moisture observation station
- meteorological observation station
- research catchment

### Simulation based on a decoupled model

Extension of an existing hydrological model:

- feedback ground water to the surface water
- feedback ground water to the unsaturated zone and vegetation
- surface inundation processes

### Robust and efficient solvers for a coupled model

- adaptive time stepping and mesh refinement
- robust multigrid solvers by combination of monotone multigrid and Newton multigrid

### Comparison of decoupled/coupled models

- Quantitative effects of coupling/decoupling versus data availability and computing time. Comparison with experimental data.
- Fast solvers allow for systematic quantitative studies: Influence of small scale data variability on relevant output data (water table).

## Future Perspectives

- nonlinear vegetational effects, evaporation and rainfall infiltration
- dynamics of surface water
- upscaling to larger catchments

## Cooperations

Within Sfb:
A2, B2, C2 (adaptive multigrid), A3, C1 (domain decomposition techniques), B1, B3 (numerical analysis), C4 (ode solvers)
Beyond Sfb:
P. Bastian (Heidelberg), R.H.W. Hoppe (Augsburg), V. Krysanova (Potsdam), B. Merz (Potsdam), R. Nochetto (Maryland), J. Schönfelder (Potsdam), P. Troch (Wageningen), G. Wittum (Heidelberg)

## Relations to other projects

**Bänsch:** DFG–Research Center, Project C1 *"Coupled systems of reaction–diffusion equations and application to the numerical simulation of direct methanol fuel cell problems."*
DFG–Research Center, Project C2 *"Efficient simulation of flows in semiconductor melts."*
**Bronstert:** BMBF–Project *"Options for Water Resources management in the Havel River Catchment."*